

WHAT IS CLAIMED IS:

1 Claim 1. A method of producing a nanoporous open-cell functionalized silica
2 gel having a plurality of open channels within the gel structure and silanol (Si-OH)
3 groups on the surface comprising

4 (a) gelling a silica sol solution to form a wet silica gel;
5 (b) maintaining the silica gel at a temperature in the range of from about 40 to
6 about 80 °C in a moist state to obtain a wet nanoporous silica gel having a plurality of
7 open channels within the gel structure and silanol (Si-OH) groups on the surface; and
8 (c) reacting a ligand group with the surface silanol groups to introduce a
9 functionalized group effective for selective adsorption or reaction catalysis.

1 Claim 2. A method for producing a chemically surface modified silica gel
2 comprising:

3 (a) gelling a silica sol solution to form a wet silica gel;
4 (b) maintaining the silica gel at a temperature in the range of from about 40 to
5 about 80°C in a moist state to obtain a wet nanoporous silica gel having a plurality of
6 open channels within the gel structure and silanol (Si-OH) groups on the surface
7 thereof; and
8 (c) reacting the wet nanoporous silica gel with a reactive ligand introducing
9 compound in an aqueous alcoholic medium under an inert atmosphere and at an
10 elevated temperature within the range of from about 40°C to about 80°C to cause the
11 ligand introducing compound to condense and react with said surface silanol groups
12 to thereby obtain said chemically surface modified silica gel; and
13 (d) optionally, drying the chemically surface modified silica gel.

1 Claim 3. A method for producing a chemically surface modified silica gel
2 comprising the steps of:

3 (a) reacting a silica precursor with a reactive ligand introducing compound in
4 an aqueous alcoholic medium under an inert atmosphere and at an elevated
5 temperature within the range of from about 40°C to about 80°C to cause the ligand
6 introducing compound to condense and react with said silanol groups before gelation
7 and subsequently adjusting the pH value of the solution to induce gelation, to thereby
8 obtain said chemically surface modified silica gel; and

9 (b) optionally, drying the chemically surface modified silica gel.

1 Claim 4. A chemically surface modified silica gel produced by the method of
2 claim 1.

1 Claim 5. A chemically surface modified silica gel produced by the method of
2 claim 2.

1 Claim 6. The chemically surface modified silica gel according to claim 5
2 wherein the ligand introducing compound is 3-mercaptopropyltrialkoxysilane.

1 Claim 7. A chemically surface modified silica gel produced by the method of
2 claim 3.

1 Claim 8. The chemically surface modified silica gel according to claim 7
2 wherein the ligand introducing compound is 3-mercaptopropyltrialkoxysilane.

1 Claim 9. A method of removing metallic impurities from a liquid which
2 comprises contacting the liquid with the chemically surface modified silica gel of any
3 one of claims 1-8.

4 Claim 10. A method of concentrating metallic content in a liquid which
5 comprises contacting the liquid with the chemically surface modified silica gel of any
6 one of claims 1-8.

7 Claim 11. A method of separating two or more metallic impurities from a
8 solution of the mixture of metallic impurities which comprises passing the solution
9 mixture through a column packed with the chemically surface modified silica gel of
10 any one of claims 1-8.

1 Claim 12. A method of recovering metal from a low-concentration feed
2 solution which comprises contacting the feed solution with the chemically surface
3 modified silica gel of any one of claims 1-8.

1 Claim 13. A method of producing a nanoporous open-cell silica gel having a
2 plurality of open channels within the gel structure and silanol (Si-OH) groups on the
3 surface comprising

4 (a) gelling a silica sol solution to form a wet silica gel; and
5 (b) maintaining the silica gel at a temperature in the range of from about 40 to
6 about 80°C in a moist state to obtain a wet nanoporous silica gel having a plurality of
7 open channels within the gel structure and silanol (Si-OH) groups on the surface.

1 Claim 14. A method for preparing a chemically surface modified silica gel
2 effective for adsorbing a target specie from a liquid containing said target specie
3 suspended or dissolved therein, said method comprising

4 (1) selecting a ligand molecule having a first functional group at one end
5 thereof reactive with the silanol groups of silica and a second functional group at an
6 opposed end thereof, said second functional group strongly binding to said target

7 specie, as determined by at least one of bond energy between the second functional
8 group and target specie or solubility product constant, K_{sp}; and

9 (2) reacting wet silica gel with the selected ligand in a hydrophilic co-solvent.

1 Claim 15. A chemically surface modified silica gel produced by the method of
2 claim 14 which further comprises

3 (a) gelling a silica sol solution to form a wet silica gel;

4 (b) maintaining the silica gel at a temperature in the range of from about 40 to
5 about 80 °C in a moist state to obtain a wet nanoporous silica gel having a plurality of
6 open channels within the gel structure and silanol (Si-OH) groups on the surface
7 thereof; and

8 (c) reacting the wet nanoporous silica gel with a reactive ligand introducing
9 compound in an aqueous alcoholic medium under an inert atmosphere and at an
10 elevated temperature within the range of from about 40°C to about 80°C to cause the
11 ligand introducing compound to condense and react with said surface silanol groups
12 to thereby obtain said chemically surface modified silica gel.

1 Claim 16. A chemically surface modified silica gel produced by the method of
2 claim 14 which further comprises

3 reacting a silica precursor with said selected ligand molecule in said hydrophilic
4 co-solvent under an inert atmosphere and at an elevated temperature of from about
5 40°C to about 80°C to cause the selected ligand molecule to condense and react with
6 said silanol groups before gelation and subsequently adjusting the pH value of the
7 solution to induce gelation.

1 Claim 17. A method of separating a target specie from a ligand containing
2 said target specie which comprises contacting the liquid with the chemically surface
3 modified silica gel of claim 15 or claim 16.

1 Claim 18. A chemically surface modified silica gel according to claim 15 or
2 claim 16 wherein said second functional group strongly binds to an organic target
3 specie.

1 Claim 19. A method for removing oil or other organic chemical contaminant
2 spilled on the surface of a body of water, comprising contacting the contaminated
3 surface of said body of water with the chemically surface modified silica gel according
4 to claim 18 whereby the oil or other organic chemical contaminant at least
5 substantially adsorbed by said gel and thereafter removing the gel from the surface of
6 said body of water.

1 Claim 20. A chemically surface modified amorphous silica gel adsorbent
2 comprising

3 (i) bimodal pore size distribution of pores having pore diameters of about 10
4 nanometers and about 10 microns;
5 (ii) ligand loading of about 7.5 mmole ligand per gram silica gel; and
6 (iii) bulk density in the range of from about 0.2 to about 0.25 g/ml.

1 Claim 21. The silica gel adsorbent according to claim 18 wherein said ligand
2 comprises 3-mercaptopropyltrialkoxysilane.